

**DIVERSITY OF QUEENSLAND PARADOXOSOMATID  
MILLIPEDES (DIPLOPODA: POLYDESMIDA:  
PARADOXOSOMATIDAE)**

R. MESIBOV

*Queen Victoria Museum and Art Gallery, Launceston, Tas 7250*

*(E-mail: mesibov@southcom.com.au)*

**Abstract**

Paradoxosomatids are the most widespread and abundant native millipedes in mainland Australia. The Queensland paradoxosomatid fauna currently consists of five inadequately described species, 28 adequately described species and 199 new and undescribed species. Future collecting in non-rainforest habitats can be expected to raise the State total by at least another 10% to 250 species.

**Introduction**

Of the eight native millipede orders in Australia, Polydesmida is the most diverse and currently accounts for *ca* 60% of described Australian species (Mesibov 2006-07). Most polydesmidans in mainland Australia are in Paradoxosomatidae, the largest of all millipede families and native to every continent except North America and Antarctica (Hoffman 1982).

Thirty-one species of paradoxosomatids have been described from Queensland (Table 1). The list is slightly inflated as five of the names refer to inadequately described species whose types are either missing or the wrong sex (only mature male polydesmidans can be confidently identified). Of the remaining 26 species, only eight have been described in the past 65 years. Two more paradoxosomatids are here added to the State list from the fauna of northern New South Wales (Table 1), bringing the total of named Queensland paradoxosomatids to 33 and the total of recognisable named species to 28. These tallies ignore three subspecies noted in Table 1; two were described at the same time as the nominate subspecies, while the third was described in 1987. For taxonomic details of all species listed, see Mesibov (2006-07).

Thousands of specimens of Queensland Paradoxosomatidae have been added to museum collections in recent years, chiefly by Geoff Monteith and colleagues at the Queensland Museum and by CSIRO entomologists based at the Australian National Insect Collection. In this article I report on a recent sorting of that material, which has yielded a remarkably large number of new species and added many new locality records for known species.

**Materials and methods**

Results summarised here are from an unpublished study for the Natural Heritage Assessment Section of the Department of the Environment and Heritage (now Department of the Environment and Water Resources), Canberra. The DEH project was carried out by Mark Harvey (Western Australian Museum), Cathy Car (Charles Sturt University) and myself in 2006 and 2007 and required us to sort to species all native

Paradoxosomatidae in Australian museums. We also did a limited amount of additional collecting.

Museum collections contain paradoxosomatids collected by hand, pitfall trapping, flight intercept trapping, pyrethrum knock-down and Berlese extraction of leaf litter and moss. The only specimens reliably identifiable to species are mature males. These are sorted on the structure of the modified legs known as *gonopods*, which are used to transfer sperm during mating. For the DEH project, mature males (and sometimes associated females) were removed from mixed samples, sorted, relabelled and separately registered.

The Queensland subset of the DEH project results is my own work. Named species were identified using descriptions and redescrptions in the taxonomic literature. New species were assigned, where feasible, to existing genera (see Results). Species were documented with label information, museum registration numbers, colour images, gonopod drawings, brief notes on key characters and distribution maps. This documentation, in HTML format, is available on CD-ROM in the Queensland Museum with restricted access. All sorted specimen lots have been labelled with name or sorting code.

For project purposes, a small number of locality records with a spatial uncertainty greater than  $\pm 10$  km were excluded. The final list of 913 one-species locality records for Queensland consisted of:

- 744 records from the Queensland Museum (Brisbane),
- 95 from the Australian National Insect Collection (Canberra),
- 27 from the Australian Museum (Sydney),
- 10 from Museum Victoria (Melbourne),
- 3 from the Western Australian Museum (Perth),
- 1 from the South Australian Museum (Adelaide), and
- 33 from museums overseas (literature records for types and vouchers).

Each locality was defined as a unique latitude/longitude pair. Most pairs were taken from the collecting-event database maintained by the Queensland Museum. Other pairs were taken from specimen labels after checking agreement with locations expressed in words, or were assigned to such locations using the Geoscience Australia gazetteer, paper maps or the Australian National Insect Collection online specimen database.

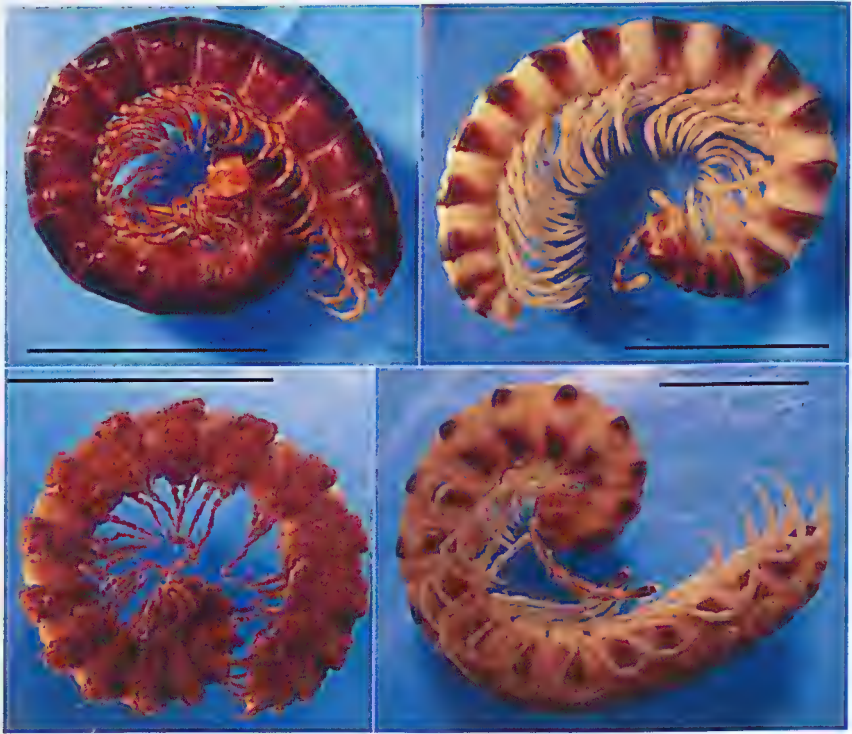
## Results

### *Species diversity*

Twenty-one of the 28 adequately described species were sorted from museum collections (Table 1, Fig. 1). In most cases the sortings were rediscoveries of taxa not reported since their first description. It might be expected that the list of 28 would be biased towards relatively abundant and widespread species and, of the 17 species recorded from 10 or more localities, 15 have names.

**Table 1.** List of described species of Queensland Paradoxosomatidae. Under Status, Y = adequately described, ? = inadequately described (e.g., known from female (F) only), + = new records, - = no new records since description. Under 1st Year is given the known or bounded date of first collection; 1910-13 = E. Mjöberg expeditions, 1891-93 = R. Semon expeditions. The two species marked with an asterisk (\*) are NSW species reported here from Qld for the first time.

Species	Status	1st year
<i>Atropisoma elegans</i> Silvestri, 1897	?, F only	<1897
<i>Aulacoporus affinis</i> Verhoeff, 1924	Y, -	1910-13
<i>Aulacoporus castaneus</i> Verhoeff, 1924	Y, +	1910-13
<i>Aulacoporus yarrabahus</i> Verhoeff, 1924	Y, +	1910-13
<i>Australodesmus divergens</i> Chamberlin, 1920	Y, +	<1920
<i>Brochopeltis mjobergi</i> Verhoeff, 1924 (2 subspp.)	Y, +	1910-13
<i>Cladethosoma uncinatum</i> Jeekel, 1987	Y, -	1910-13
<i>Desmoxytoides hasenpuschorum</i> Mesibov, 2006	Y, +	1971
' <i>Eustrongylosoma</i> ' <i>transversefasciatum</i> Silvestri, 1897	?, F only	<1897
<i>Helicopodosoma vittigerum</i> Verhoeff, 1924	Y, -	1910-13
<i>Heterocladosoma asperum</i> (L. Koch, 1867)	Y, +	<1867
<i>Heterocladosoma bifalcatum</i> (Silvestri, 1898)	Y, +	1891
<i>Heterocladosoma hamuligerum</i> (Verhoeff, 1924)	Y, +	1910-13
<i>Heterocladosoma trabeatum</i> Jeekel, 1987	Y, +	<1987
<i>Heterocladosoma tranversetaeniatum</i> (L. Koch, 1867) (2 subspp.)	Y, +	<1867; 1924
<i>Mjobergodesmus annulatus</i> Verhoeff, 1924	Y, +	1910-13
<i>Paraualiosoma malandense</i> (Verhoeff, 1924)	Y, +	1910-13
* <i>Parwalesoma rubriventris</i> (Verhoeff, 1928)	Y, +	1890
<i>Phyllocladosoma annulatipes</i> (Verhoeff, 1924)	Y, +	1910-13
<i>Phyllocladosoma broelemanni</i> (Verhoeff, 1941)	Y, +	1936?
' <i>Polydesmus</i> ( <i>Strongylosoma</i> )' <i>dubium</i> L. Koch, 1867	?	<1867
' <i>Polydesmus</i> ( <i>Strongylosoma</i> )' <i>rubripes</i> L. Koch, 1867	?, F only	<1867
<i>Pseudostrongylosoma sjoestedti</i> Verhoeff, 1924	Y, +	1910-13
<i>Solaenodolichopus annulatus</i> Verhoeff, 1941 (= <i>Solaenodolichopus pruvoti</i> (Broelemann, 1931))	Y, -	1936
<i>Solaenodolichopus teres</i> (Verhoeff, 1924)	Y, -	1910-13
<i>Solaenodolichopus vittatus</i> (Verhoeff, 1924) (2 subspp.)	Y, +	1910-13
<i>Streptocladusoma albovittatum</i> Jeekel, 1980	Y, -	1945
<i>Streptocladusoma dissimile</i> Jeekel, 1980	Y, -	1948
<i>Streptocladusoma solum</i> Jeekel, 1987	Y, +	1980
' <i>Strongylosoma</i> ' <i>semoni</i> Attems, 1898	?, F only	1891-93
<i>Tholerosoma corrugatum</i> Mesibov, 2006	Y, +	1986
<i>Tholerosoma monteithi</i> Mesibov, 2006	Y, +	1983
* <i>Walesoma helmsii</i> Verhoeff, 1928	Y, +	1890



**Fig. 1.** Some Queensland paradoxosomatid millipedes. Top left: undescribed *Solaenodolichopus*, Border Ranges. Top right: *Mjoebergodesmus annulatus*, Cairns area. Bottom left: *Tholerosoma monteithi*, Wet Tropics; note coating of soil particles on each body ring. Bottom right: undescribed *Paraustraliosoma*, Massey Range. Scale bar for *Paraustraliosoma* = 5 mm, others = 10 mm.

Both *Heterocladosoma transversetaeniatum* (L. Koch, 1867) and *Solaenodolichopus vittatus* (Verhoeff, 1924) have published subspecies. Both are represented by a large number of specimens in the collections and substantial variation is apparent in both, exceeding the variation used to diagnose subspecies. These two species are probably best regarded as species complexes pending further work on the taxonomy of the respective genera.

Another 199 species were sorted (Fig. 1), none of which was identified as one of the well-known 'tramp' paradoxosomatids of the Pacific region (Shelley and Lehtinen 1998). I referred 96 of these new natives to existing genera. Two of the genera, *Antichiropus* Attems, 1911 and *Notodesmus* Chamberlin, 1920, have not previously been reported from Queensland. One monotypic genus, *Brochopeltis* Verhoeff, 1924, retains that special status, but all other monotypic genera expanded during the sorting: *Australodesmus* Chamberlin,

1920 (now contains 7 spp.), *Mjoebergodesmus* Verhoeff, 1924 (8 spp.), *Paraustraliosoma* Verhoeff, 1924 (20 spp.), *Pseudostrongylosoma* Verhoeff, 1924 (2 spp.) and *Walesoma* Verhoeff, 1928 (5 Queensland spp., 2 New South Wales spp.). The greatest expansion was in *Solaenodolichopus* Verhoeff, 1924, a well-defined genus which has grown in Queensland from three to 47 sorted species.

The remaining 103 new species have been assigned to codes rather than genera. The relationships of these species are far from clear and for sorting purposes I decided not to attempt to 'stretch' diagnoses of existing genera to accommodate oddities. A large proportion of coded species are much smaller as adults (6-12 mm long) than any previously described Australian paradoxosomatids and were collected mainly by the Berlese method.

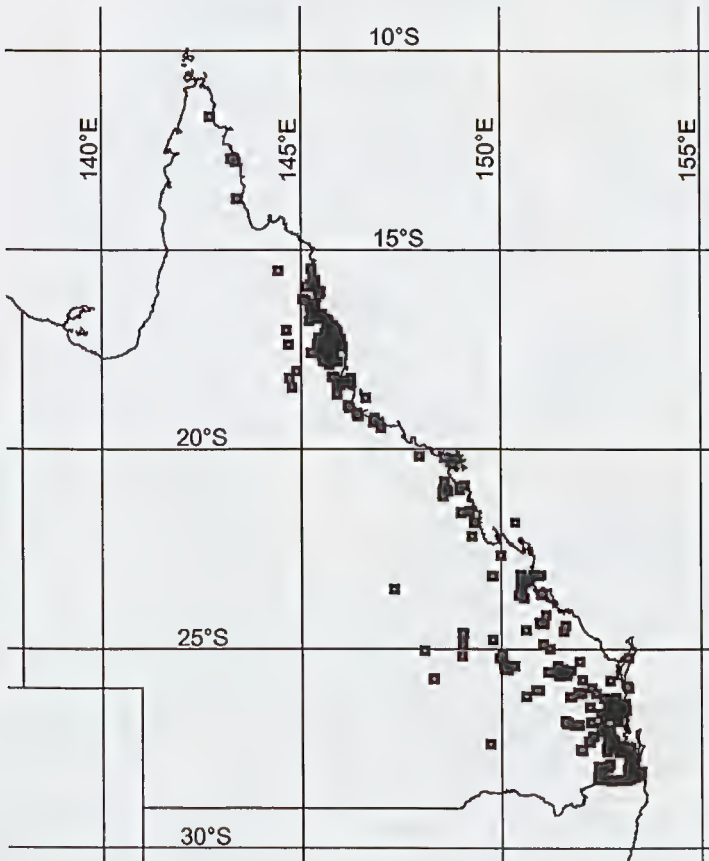


Fig. 2. Localities for Paradoxosomatidae sorted to species in Queensland.

### Biogeography and sampling

The sole Queensland record for *Cladethosoma uncinatum* Jeekel, 1987, 'Christmas Creek', is geographically ambiguous and is excluded in the analysis that follows.

Paradoxosomatids were recorded from 431 localities in Queensland, largely near the coast (Fig. 2). More than half the 226 species (117) were recorded from one locality only and only 32 species (14%) were recorded from five or more localities.

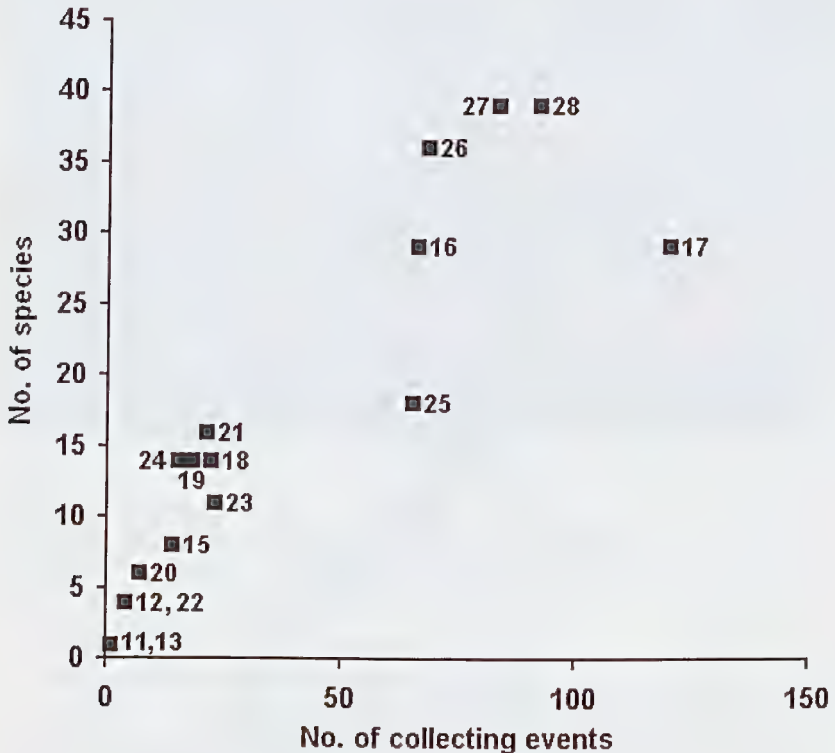


Fig. 3. Increase of species recorded with search effort. Each point is from a latitude class from 11° to 28°S; the latitude class is marked next to the point. No species were recorded from 14°S. See text for further explanation.

Most species were recorded in the Wet Tropics and in southeastern Queensland, which were also the most intensively sampled areas. The effect of this sampling bias is indicated graphically in Fig. 3. Here the number of species recorded in each 1° latitude class is plotted against search effort,

approximated as the number of collecting events in that latitude class; each collecting event is a unique locality and collecting date (the day, month and year collecting ceased in the case of traps left open for long periods). Although the relationship looks roughly linear, it should not be concluded that if every 1° latitude-block near the coast were searched with equal effort, then the same number of species would be collected. Some parts of Queensland are undoubtedly more paradoxosomatid-rich than others. However, as Fig. 3 suggests, collecting to date has not unequivocally demonstrated that the Wet Tropics and the southeast are dramatically richer in paradoxosomatid species.

### *Biogeographical patterns*

*Heterocladosoma bifalcatum* (Silvestri, 1898) was first reported from Cairns but Jeekel (1987), who described a specimen from Colosseum [85 km S of Gladstone], suspected the Cairns record to be an error. Recently, Rowe and Sierwald (2006) redescribed this conspicuous and locally abundant species from the Sydney area. All other records from the DEH project (Fig. 4) are from southeastern Queensland, from near Childers south to the New South Wales border. It seems likely that *H. bifalcatum* is a southeast Queensland native that has been introduced elsewhere. It joins another Australian paradoxosomatid, *Akamptogonus novarae* (Humbert & de Saussure, 1869), in the interesting class of 'native exotics': species introduced and established well outside their native range but still within their broader native region. For more information on *A. novarae*, believed to be an eastern Australian native but now resident in Tasmania, Western Australia, Norfolk Island, New Zealand and Hawaii, see Mesibov (2006-07).

New locality records for the other named species have not greatly extended their known ranges. However, enough records have now accumulated to reveal mosaic parapatry between species in *Aulacoporus* Verhoeff, 1924, *Australodesmus* Chamberlin, 1920, *Heterocladosoma* Jeekel, 1968 (Fig. 4), *Mjoebergodesmus* Verhoeff, 1924, *Paraustraliosoma* Verhoeff, 1924, *Phyllocladosoma* Jeekel, 1968, *Solaenodolichopus* Verhoeff, 1924 and *Walesoma* Verhoeff, 1928. Mosaic parapatry (distributions arranged like adjacent tiles in a mosaic, with very little overlap) is common in millipede genera (Mesibov 2003) and was first reported for Queensland paradoxosomatids in *Tholerosoma* (Mesibov 2006).

Another biogeographical pattern in the new locality data is high species turnover across the Black Mountain Barrier (BMB) between Cairns and Mossman in the Wet Tropics. The BMB is regarded as a former dry-forest barrier between two rainforest refugia (Schneider *et al.* 1998, Yeates and Monteith in press). Among the small number of paradoxosomatids occurring on both sides of the BMB, *Mjoebergodesmus annulatus* Verhoeff, 1924 is remarkable for having two colour morphs: the typical dark/light annulated form in the Cairns area and an all-dark form west of Mossman.

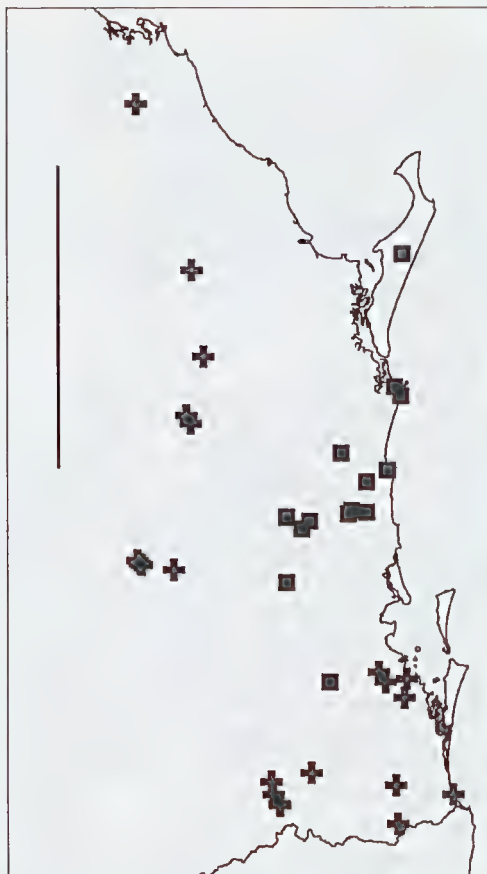


Fig. 4. Localities for *Heterocladosoma bifalcatum* (crosses) and *H. hamuligerum* (squares) in SE Queensland. Scale bar = 200 km.

### Discussion

Paradoxosomatidae in Australia have an enormously wide ecological range. They are abundant in tropical rainforest in northern Queensland and in cool temperate rainforest in northwestern Tasmania (Mesibov 2000), in sandy coastal heaths and in tall, dense forest. Their dry-country limits have not yet been mapped, but specimens collected well inland in Queensland were sorted in this study. Paradoxosomatids have also been collected by Mark Harvey (pers. comm.) in semi-arid Western Australia and by Cathy Car (pers. comm.) in semi-arid New South Wales. To judge from the DEH project sorting, larger species of *Heterocladosoma* and *Solaenodolichopus* (25-40 mm long as adults) may be particularly successful in the Queensland dry country.



With further searching in dry, inland areas, it is reasonable to expect the Queensland paradoxosomatid species total to increase by 10% to *ca* 250 species. The real total may be much higher if narrow-range endemism is as prevalent in western Queensland as it is in the coastal strip. Entomologists working in the dry country can assist in discovering this diversity by collecting surface-active millipedes at night and after rain. Specimens can be killed, preserved and stored in 70-80% ethanol and I recommend that they be deposited in the Queensland Museum.

While the discovery of millipede diversity is relatively straightforward, the documentation of that diversity suffers from a lack of specialists. It will be many years before the backlog of new Australian genera and species created by the DEH project can be cleared by formal taxonomic publication.

### Acknowledgements

I am very grateful to Cameron Slatyer, formerly head of the Natural Heritage Assessment Section (DEH), for supporting this work with funds and enthusiasm. For their patience and assistance with work in collections I thank Graham Milledge (Australian Museum); Natalie Barnett, Matt Colloff and Jacqui Recsei (Australian National Insect Collection); Peter Lillywhite and Rachel McBride (Museum Victoria); Mark Harvey and Julianne Waldock (Western Australian Museum); and especially Robert Raven and Owen Seaman (Queensland Museum).

### References

- HOFFMAN, R.L. 1982. Diplopoda. Pp 689-724, in: Parker, S.P. (ed.), *Synopsis and classification of living organisms*, Vol. 2. McGraw-Hill, New York; 1232 pp.
- JEEKEL, C.A.W. 1987. Millipedes from Australia, 11: Australiosomatini from Queensland (Diplopoda, Polydesmida, Paradoxosomatidae). *Beaufortia* 37: 11-41.
- MESIBOV, R. 2000. An overview of the Tasmanian millipede fauna. *Tasmanian Naturalist* 122: 15-28.
- MESIBOV, R. 2003. Lineage mosaics in millipedes. *African Invertebrates* 44: 203-212.
- MESIBOV, R. 2006. Dirt-encrusted and dragon millipedes (Diplopoda: Polydesmida: Paradoxosomatidae) from Queensland, Australia. *Zootaxa* 1354: 31-44.
- MESIBOV, R. 2006-07. Millipedes of Australia (website). Accessed 6 August 2007. <http://www.qvmag.tas.gov.au/zoology/millipedes/index.html>
- ROWE, M. and SIERWALD, P. 2006. Morphological and systematic study of the tribe Australiosomatini (Diplopoda: Polydesmida: Paradoxosomatidae: Paradoxosomatidae) and a revision of the genus *Australiosoma* Brölemann. *Invertebrate Systematics* 20: 527-556.
- SCHNEIDER, C.J., CUNNINGHAM, M. and MORITZ, C. 1998. Comparative phylogeography and the history of endemic vertebrates in the Wet Tropics rainforests of Australia. *Molecular Ecology* 7: 487-498.
- SHELLEY, R.M. and LEHTINEN, P.T. 1998. Introduced millipedes of the family Paradoxosomatidae on Pacific Islands (Diplopoda: Polydesmida). *Arthropoda Selecta* 7(2): 81-94.

SILVESTRI, F. 1898. Note sui Chilopodi e Diplopodi conservati nel Museo Zoologico di Firenze. I. Alcuni nuovi Diplopodi de Queensland (Cairns). *Bullettino della Società Entomologica Italiana* **29**: 225-232.

YEATES, D.K. and MONTEITH, G.B. (in press). The invertebrate fauna of the Wet Tropics: diversity, endemism and relationships. In: Stork, N. and Turton, S. (eds), *Living in a dynamic tropical forest landscape*. Blackwell Publishing.